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Published in:
Transactions of the Institute of British Geographers

DOI:
10.1111/tran.12408

Publication date:
2021

Licence:
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Document Version
Publisher's PDF, also known as Version of record

Accepted: 12 August 2020

DOI: 10.1111/tran.12408

WILEY IBG Royal Geographical Society with IBG

REGULAR PAPER

Environmental vulnerability and resilience: Social differentiation in short- and long-term flood impacts

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Scottish Executive

This paper reports household questionnaire survey results on vulnerability and resilience to flooding from one of the largest and most representative samples (n = 593) of households up to 12 years after they were flooded, and is one of the first to provide detailed analysis of social differentiation in long-term flood impacts. A novel finding is that social differentiation in flood impacts is relatively small soon after a flood, but widens over time, with socially disadvantaged groups displaying less recovery. The patterns of social differentiation in vulnerability and resilience to flooding differ markedly according to the type and timescale of the impact, with some normally socially advantaged groups (e.g., professionals and homeowners) being most vulnerable to short-term impacts. Consistent with some existing studies, we found that older residents (age 70+) have greater resilience to flood impacts, although our sample may not capture the frailest individuals. As in previous research, low income is linked to lower resilience, particularly in the long term. We find that prior experience of flooding, despite enhancing preparedness, overall erodes rather than enhances resilience to flooding. Flood warnings are effective at reducing vulnerability to short-term impacts. Underlying influences on resilience to natural disasters are complex and may only be revealed by multivariate analysis and not always be evident in simple observed patterns. The paper concludes that vulnerability and resilience to flooding are sensitive to financial resources, institutional support (chiefly from a landlord), and capacity to deal with disruption (chiefly time availability, which is low among professionals and high among retired people). An implication of these findings is that existing indices of flood vulnerability that use multiple measures of social deprivation should be used with caution, as not all conventional aspects of social deprivation are necessarily associated with greater vulnerability to flood impacts.

KEYWORDS
environmental resilience, environmental vulnerability, flooding, flood-risk management, household questionnaire survey, Scotland

1 | INTRODUCTION

Flooding is a substantial natural hazard in many parts of the world and is the main natural hazard faced in northern Europe, where climate change is thought to be increasing the frequency and magnitude of flood events (IPCC, 2018; Mitchell, 2003; Penning-Rowsell, 2015). Urbanisation in northern Europe has tended to occur in the most at-risk low-lying coastal and fluvial areas, exposing population to risk (Baxter, 2005; Hall et al., 2003). In developed countries, the vulnerability of human well-being to flooding, and the potential to increase resilience through various social and technological interventions beyond hard-engineered defences, is increasingly being recognised in flood-risk management, such as river catchment management, property-level protection measures, and flood warning schemes (Dawson et al., 2011; Furedi, 2007). This paper uses one of the largest and most representative surveys of flooded households to reveal important social patterns in vulnerability and resilience to flood impacts. The households in the sample were flooded in Scotland, United Kingdom, between 1993 and 2005, but most of the findings and conclusions are generalisable beyond Scotland and the UK.

Some evidence suggests that certain types of individuals and households are more vulnerable to the impacts of flooding than others, for example those on low incomes, the elderly, women, children, and people whose activities are limited by ill-health or disability (Evans et al., 2004; Kaźmierczak et al., 2015b; Sayer et al., 2017; Tapsell et al., 2002). However, quantitative evidence for these claims is neither extensive nor consistent, particularly in relation to long-term impacts.

Another gap in existing knowledge is that most studies have focused on a single flood event, yet many locations experience repeated flooding. There are contrasting perspectives in the literature on the effect of repeated flooding but limited evidence. On the one hand, increased knowledge and preparedness arising from a previous flood may increase resilience to subsequent flood impacts (Kirschenbaum, 2002). On the other hand, lasting impacts from a previous flood may deplete psychological resilience (Medd et al., 2015). Mason et al. (2010) found that repeated flooding increased post-traumatic stress, but Greene et al. (2015) found no effect of repeated flooding on self-reported psychological distress.

Qualitative and quantitative evidence has gleaned much about the nature of flood impacts, mainly in economic terms and the recovery process. However, less is known about the social patterns in long-term impacts (Alderman et al., 2012), despite qualitative evidence suggesting that flood impacts can be very long lasting or even permanent (Medd et al., 2015). Quantitative studies have generally been conducted relatively soon after a flood, although Lamond et al. (2015) assessed flood victims somewhat longer (five years) after being flooded.

The analysis reported in this paper is novel in three regards. First, it is one of the first quantitative studies to explicitly differentiate between short- and long-term flood impacts over a wide range of impacts, and so be able to focus on social patterns in the recovery process. Second, it is only the third quantitative study to capture the effect of repeated flooding. Third, it is based on one of the largest, most comprehensive and representative samples of flooded households undertaken to date in the UK.

The paper aims to:

1. Identify social characteristics linked with short- and long-term flood impacts.
2. Assess the importance of mitigating factors (assistance and services) and severity of flooding relative to social characteristics.
3. Assess the proposition that prior experience of flooding increases resilience to subsequent flooding.

The analysis reveals social differentiation in the recovery process, with social inequalities widening over time. In particular, low-income groups report greater long-term impacts than higher-income groups. Some socially advantaged groups, such as homeowners, report greater short-term impacts, in particular tangible material losses. Short-term intangible impacts, mostly relating to disruption, are widely felt across social categories. Older people report lower levels of short- and long-term impact, contrary to assumptions in existing measures of flood vulnerability, including those used in flood-risk management. Those who have previously been flooded report greater long-term impacts arising from the most recent flood, which we interpret as an erosion of resilience arising from having been previously flooded.

2 | CONCEPTUAL BACKGROUND AND EXISTING EVIDENCE

2.1 | Vulnerability and resilience

The concept of environmental vulnerability frames why certain locations and population sub-groups are more exposed to, or less able to withstand or recover from, natural hazards (Tapsell et al., 2002; Watson et al., 2009). Vulnerability to

natural hazards has been linked to underlying socio-economic inequalities, social relations, political priorities and values, and systems of governance and representation (Cutter et al., 2003; Watts & Bohle, 1993), and environmental issues more generally have been seen as an arena of inequality and injustice (Johnson et al., 2007) and political power and exploitation (McCarthy, 2019). Resilience is seen as a wider set of adaptive and transformational processes that can set communities onto new evolutionary pathways rather than simply "bouncing back" to the same conditions prior to a natural disaster (Cutter, 2020; Patel et al., 2017).

We adopt the influential and widely used definition of vulnerability proposed by Cutter (2006), differentiating between three components: exposure, resistance, and resilience. Our survey data relate to a range of short- and long-term impacts on households of being flooded. As such, we do not have data on community- or system-level change and transformation as would be required for a comprehensive assessment of community resilience. The empirical analysis in this paper relates to short-term resistance and long-term resilience to flood impacts, although existing literature on social patterns in exposure to risk is briefly reviewed in order to provide context. Exposure refers to the degree to which people, businesses and infrastructure are in potential harm's way, e.g., how likely are they to be flooded, to what extent and how often? Resistance[1] refers to the ability to withstand, repel, and cope with the immediate effects of a flood, e.g., flood defences, building standards, emergency response, and capacity to maintain key social and economic functions and kick-start the recovery process. Resilience refers to the ability to recover to pre-disaster levels of functionality and well-being, which may involve temporary or permanent adaptation, e.g., rebuilding/renovation, replacement of possessions, re-establishing normal family life, and coming to terms with ongoing flood risk. Long-term recovery may be incomplete, with pre-flood levels of functionality or well-being never being regained (Begg et al., 2015; Tunstall et al., 2006).

The evidence-base on social vulnerabilities affecting long-term recovery from flooding is poorly developed. Yet governments seek to incorporate social factors in flooding-risk management, such as encouraging preparedness and awareness among at-risk populations and taking account of socially vulnerable population sub-groups in risk assessment and emergency planning (Begg et al., 2015; Brown & Damery, 2002; Cutter et al., 2013; Tapsell et al., 2002; Werritty, 2006).

2.2 | Flooding and the nature of flood impacts

Flooding typically occurs in response to extremes of rainfall inland, or wave and storm activity along the coast. Fluvial flooding, caused by a river overtopping its banks and inundating immediately adjacent areas, often occurs over a time period that enables flood warnings to be issued up to 3 hour in advance (Geddes et al., 2017). Surface water flooding (sometimes termed "pluvial flooding") is caused by intense, highly localised rainfall (typically summer thunderstorms) for which warnings are rarely possible (Houston et al., 2011). The impact of coastal flooding is strongly dependent on the state of the tide and can be intensified by storm surges and wave action, all of which can be forecast and means warnings can be issued. Structural defences are often in place in some of the highest risk areas, but recently there have been moves away from heavily-engineered solutions on grounds of cost, unnaturalness, and the selective protection they provide, often to higher-value properties with wealthier occupants (Houston, 2016; Johnson et al., 2007). The locations selected in the survey that provided the empirical database for this study were partly selected to ensure that all three types of flooding were adequately represented.

Preparedness for flooding involves a complex set of drivers of which the availability and use made of flood warnings is a key element (Geddes et al., 2017). Also significant is whether or not a property has been protected by property flood resilience measures (also known as property-level protection) which seek to impede the ingress of flood water (door guards and airbrick covers) and lower the impact (elevating kitchen appliances, re-locating electrical sockets and replacing carpets with hard floor surfaces). Property flood resilience measures had not been widely promoted by the time of the 2006 survey, although they are now viewed as a key part of the tool kit for managing flooding (Scottish Government, 2019). The take up of both flood warnings and property resilience measures reflects an individual's flood history, their personality, and their risk appetite (Geddes et al., 2017). Finally, flood preparedness can also involve taking out insurance, the take up of which involves complex issues of availability (Ball et al., 2013) and affordability (Penning-Rowsell, 2019). The recently implemented Flood Re programme in the UK (Browning, 2019) seeks to address both issues by selective capping of premium levels and promoting greater availability.

The social and personal impacts of floods, although often intangible, can be substantial and long lasting (Greene et al., 2015; Lamond et al., 2015; Medd et al., 2015; Sims et al., 2009; Tunstall et al., 2006). Financial losses and disruption arising from damage to infrastructure and facilities can cause economic harm to livelihoods and businesses (Committee on Climate Change, 2017).

The short-term impacts of flooding on individuals and households are experienced in terms of both concrete loss (damage to housing, loss of possessions, relocation to temporary accommodation) and emotional trauma (unexpected nature of event, deposition of silt and sewage, powerlessness in organising repairs; Medd et al., 2015; Werritty et al., 2007). In the longer term, strains in maintaining family life and anxiety over future heavy rainfall add to anxiety. Being flooded thus initially generates loss and disruption and over time affects ontological security, with some victims of flooding reporting that their home no longer feels theirs (Sims et al., 2009).

A variety of mitigating factors have been linked with lowered flood impacts, in many studies based on standard measures of mental health and trauma: contents insurance; flood warnings; taking actions prior to a flood; and receiving assistance (Lamond et al., 2015; Tunstall et al., 2006). Severity of flooding (in particular depth of water in the home) has been strongly linked with impacts on mental health (Lamond et al., 2015; Tunstall et al., 2006). Length of time displaced from home after a flood was a strong predictor of impact on mental health (Lamond et al., 2015).

2.3 | Social differentiation in exposure to flood risk

Socially deprived groups have been shown to be more exposed to coastal flood risk in the UK (Sayers et al., 2017), England and Wales (Walker et al., 2006), and Scotland (Kaźmierczak et al., 2015a; Werritty et al., 2007). Social renters, single parents, those in low-skilled occupations, ethnic minorities, children, and elderly people have all been shown to be more exposed to pluvial surface water flood risk in cities (Houston et al., 2011; Kaźmierczak & Cavan, 2011). In contrast, fluvial flood-risk areas are characterised by populations with lower levels of social deprivation, reflecting the "leafy" and sought-after nature of some riverside locations (Walker et al., 2006). Garbutt et al. (2015) found that the sick, elderly, and those on low incomes faced greater exposure to flood risk than other groups within a low-lying area of eastern England (Norfolk). This coastal/river contrast in the UK is reversed in the USA, where coastal areas, such as Miami, Florida, are the most sought-after areas by affluent residents, whereas Black and Hispanic populations are over-represented in inland flood-risk areas (Chakraborty et al., 2014).

2.4 | Social differentiation in resilience to flood impacts

Quantitative studies of flood impacts from around the world have been mainly concerned with quantifying the impact rather than identifying social differentiation per se (Assanangkornchai et al., 2007; Chae et al., 2005; Heo et al., 2008; Lamond et al., 2015; Liu et al., 2006; Mason et al., 2010; Norris et al., 2004; Paranjothy et al., 2011; Tunstall et al., 2006). Whereas such studies in developing countries focus on physical health issues (water-borne disease, malnutrition, and mortality) as reviewed in Alderman et al. (2012), mental health impacts dominate studies in developed countries.

We extract and comment on three major quantitative studies on the long-term (beyond one-year post-flood) mental health impacts of flooding, which focus on post-traumatic stress, anxiety, and/or depression. In two England-based studies, age measured in years (as opposed to age categories) was not selected by a statistical "stepwise" procedure in modelling the factors associated with poor mental health in a sample of flooded homeowners (Lamond et al., 2015) but was significant in Tunstall et al. (2006), who found that older age groups reported better mental health than younger age groups after fluvial floods.

Social differentiation also reflects personal circumstance in terms of care of family members (children, the elderly, and disabled people), alongside income levels, location within areas of social deprivation, and whether the householder owns or rents the property. Disruption arising from re-housing can affect education, social contacts, and leisure pursuits (Medd et al., 2015). In terms of caring for family members and day-to-day life, women may shoulder a disproportionate burden (Liu et al., 2006; Medd et al., 2015) with disabled people, those with pre-existing health conditions, or people with susceptibility to anxiety/stress having particular support needs (mobility aids in the house, care worker, and medication; Alderman et al., 2012; Tapsell et al., 2002). Income levels also serve to differentiate resilience levels with those on lower incomes less likely to have insurance cover to replace items, repair properties, and pay for re-location (Werritty et al., 2007). People working in lower-skilled occupations may face less flexibility in taking time off work and may have less social and cultural capital, including experience or capacity to negotiate bureaucratic processes (Medd et al., 2015). Renters may have less burden but also less control over rehousing and repairs than homeowners, consistent with renting linked to poorer acute ("worst time"), although not current, mental health scores among flood victims (Tunstall et al., 2006).

Many studies have suggested that geographical context shapes vulnerability and resilience to flooding, with areas of social deprivation or "other" populations (e.g., ethnic minorities) being afforded lower priority in both immediate flood recovery and in subsequent support (Cutter et al., 2008; Medd et al., 2015; Penning-Rowsell & Wilson, 2006). By contrast,

more cohesive communities can provide greater informal social support via family and friendship networks (Greene et al., 2015; Kaźmierczak et al., 2015b; Tapsell & Tunstall, 2008). Many studies report on the widespread destruction and displacement of households in New Orleans, USA, following Hurricane Katrina in 2005, with lower socio-economic status neighbourhoods recording the most severe impacts (Cutter et al., 2014; Masozera et al., 2007). Looking at longer-term resettlement, middle-income neighbourhoods appear to be recovering the slowest, lacking the private resources to fund recovery and with lower eligibility for publicly funded programmes (Finch et al., 2010). Many studies following Hurricane Katrina focus on social/racial patterns in displacement and resettlement rates rather than social and personal impacts on individuals and households (e.g., Finch et al., 2010).

3 | METHODS AND DATA

This paper draws on systematic quantitative data from a structured questionnaire survey of 593 flood victims from a variety of locations across Scotland between one and twelve years after they were initially flooded.[2] Respondents were asked to grade the severity of a range of impacts on their household. The analysis differentiates between short-term impacts in the "response" phase and long-term impacts in the "recovery" phase. The short- and long-term impacts on households are differentiated by a range of socio-economic factors identified from the existing literature. The factors elderly, children, disability, income, occupation, and housing tenure (renting versus owning) are examined via a variety of quantitative approaches. The influence of mitigating factors is assessed (contents insurance, flood warnings, taking actions prior to a flood, and receiving assistance) as well as the severity of flooding (depth and frequency) and duration displaced from home.

Scotland was chosen for fieldwork because of a number of significant floods since the early 1990s (Werritty et al., 2007) and increasing concern by the Scottish Government on how better to manage flood risk. This concern was subsequently addressed in the Flood Risk Management (Scotland) Act 2009 which, unlike England and Wales, retained local authorities as primarily responsible for delivering flood-risk management, but with the Scottish Environment Protection Agency providing national coverage of flood warnings and mapping of flood-risk areas. A key element in this legislation was a requirement that the social costs of flooding be taken into account alongside the more readily determined economic costs, a concern that continues to exercise the Scottish Government (Kaźmierczak et al., 2015a).

3.1 | Sampling and data collection

Areas that had experienced flooding were identified from indicative national flood-risk maps (McLaughlin, 2019), information in local authority reports, and from telephone contact with staff from local authorities and the Scottish Environment Protection Agency. Residential addresses in these areas were randomly sampled (or fully sampled in areas with smaller flood envelopes).

A household was considered to have been flooded if flood water entered the home – properties were excluded if only the garden, outhouses, or communal stairwell were flooded. The survey was undertaken during the period February–September 2006 of households within selected areas that had been flooded during the period 1993–2005. Areas were selected in order to give a mix of types of flood – fluvial/river, pluvial/surface, and coastal – as well as a range of types of area – remote/rural (Culloden, Corpach, Eyemouth, Dunoon, Menstrie, Newcastleton, Orkney, and Shetland), towns (Elgin, Forres, and Hawick), and cities (Edinburgh, Glasgow, and Perth).

The survey was undertaken via a questionnaire designed to be completed by respondents. In cities and larger towns, the questionnaire was delivered by hand to each household and usually collected the next day, with a researcher assisting in its completion when necessary. Collection was focused on evenings and weekends to maximise the response rate, with up to two return visits being made. Freepost envelopes were provided when follow-up visits still failed to make contact with an adult member of the household.

Address lists of properties in areas that had been flooded were generated from lists of postal addresses. In areas with smaller flood envelopes (Elgin, Forres, and Hawick), questionnaires were delivered to all households within the historic flood envelope. In Edinburgh and Perth, where large numbers of properties were flooded, samples were drawn of properties closest to the river, with an upper limit in any one survey site of 500 properties. The water, sewerage, and drainage provider – Scottish Water – provided addresses of properties in Shettleston in the east end of Glasgow that experienced pluvial flooding in 2002, from which a geographically clustered random sample of 262 properties was drawn. For scattered rural inland and coastal locations, the questionnaire was delivered by post, respondents being provided with a freepost envelope for return.

The number of properties contacted, the number of returned questionnaires, and associated response rate in each survey site are listed in Table 1. Overall, 2,254 properties were contacted and 1,177 completed questionnaires were obtained, representing a response rate of 52.2%. Of the 1,177 completed questionnaires, 593 were from households that had been flooded and these form the sample used in the analysis reported in this paper. The non-flooded households were analysed in a comparison of flood preparedness among previously flooded and non-flooded households reported in Werritty et al. (2007).

Older people (aged 70+) comprise 22.2% of our sample, somewhat more than the 11.2% in Scotland's 2001 Census of Population. Our sample comprises 9.9% from "elementary" occupations, compared to 12.7% in the Census. Local authority tenants comprise 15.8% of our sample versus 21.6% across Scotland as a whole).[3] The number of responses in categories used in the analysis is provided later in the sample size columns (labelled "n") in Tables 3–6.

3.2 | Measurements

Respondents were asked whether flood water entered their home, the depth of flood water in their home, number of times flooded, whether they received a warning, whether they took mitigating actions prior to the flood, whether they received assistance, and the length of time they were displaced from their home. Households flooded more than once were asked to report the impacts of the most recent flood (rather than the most severe flood or combined effects of all floods), in order to capture any effect of having been previously flooded on ability to cope with, and recover from, the subsequent flood.

Some aspects of resilience and recovery derive from agencies, services, and infrastructure beyond the household. These are directly or indirectly captured by a number of household responses, specifically in relation to contents insurance, receiving a warning, being aware of risk prior to flood, taking actions prior to the flood, and receiving assistance after the flood – all of which to some degree require the availability of services, institutions, or infrastructure beyond the household.

The questionnaire invited respondents to indicate the extent to which 20 impacts (listed in Table 2) affected their household on a four-point scale: "no impact," "mild," "serious," or "extreme." As in Lamond et al. (2015), we used the household rather than the individual as the unit of analysis, asking the respondent to report impacts attributable to the flood that were experienced by the household as a whole.

The questionnaire was designed with a comparison of flood-risk perceptions and behaviour in mind, as well as information on a range of flood impacts. Our subsequent reading of the flooding vulnerability literature reveals that we had collected one of the largest, and probably the most representative, samples of flooded households and information on a wider range of impacts than previous studies (if less detailed on some impacts, particularly in relation to health).

In producing an overall impact score, "no impact" was assigned a value of zero, "mild" a value of one, "serious" a value of two, and "extreme" a value of three. Sensitivity to different scoring systems was assessed with limited impact on results. These scores were then summed to give an overall impact score. This method of aggregation assumes linear progression up the four-point Likert scale and an equal weighting of all 20 impacts (although respondents of course indicated the extent of impact from each on the four-point scale). This means the scale produced is a dimensionless index based on the summation of 20 ordinal scales, each of which can take a value of 0–3 (four unique values) but when aggregated approximates to an integer scale. The summed values for each individual household produce an overall score in the range 0–60 (60 being the maximum possible if "extreme" was ticked for all 20 listed factors). The 0–60 count scale was

TABLE 1 Response rates by survey location

Survey location	Properties contacted	Returned questionnaires	Response rate (%)
Edinburgh (Braid Burn & Water of Leith)	539	316	58.6
Elgin	412	237	57.5
Forres	444	261	58.8
Glasgow (Shettleston)	262	113	43.1
Hawick	115	55	47.8
Perth	246	126	51.2
Scattered rural & coastal (by post)	236	69	29.2
Total	2,254	1,177	52.2

TABLE 2 Impacts of flood graded by questionnaire respondents

Short-term tangible impacts	Short-term intangible impacts	Long-term impacts
Financial losses	Dealing with builders, decorators, etc.	Loss of irreplaceable or sentimental items
Loss of house value	Dealing with insurers and loss adjusters	Loss of or distress to pets
Disruption to electricity supply	Discomfort/inconvenience while getting your house back to normal	Deterioration in mental health
Used holiday entitlement	Having to leave home and possessions	Deterioration in physical health
Damage to car or van	Having to live in temporary accommodation	Strains between family members
	Stress of the flood event itself	Worry about future flooding
	Being stranded in or out of home	Loss of community spirit
	Time and effort to get your house back to normal	

converted to a more intuitive 0–100 index for reporting. The conversion was achieved by multiplying all values by 1.667 (100/60). The purpose of the analysis is to reveal social patterns in flood impacts, which a dimensionless index achieves by capturing relative differences, with no need to precisely specify flood impacts in defined units.

We categorised the 20 impact factors into one of three groups: short-term tangible impacts; short-term intangible impacts; and long-term impacts – as indicated in Table 2. Long-term impacts are those that are likely to be very long term or even have a permanent effect, in other words reflect the (in)ability to recover due to low resilience. Impacts as reported in the household survey were classified as short-term tangible, short-term intangible, or long-term on the basis of both a priori reasoning and evidence from focus group discussions with flood victims (see Werritty et al., 2007). The tangible impacts (mostly if not entirely short term) reported by flood victims need to be interpreted in light of insurers bearing most of the financial cost for the insured, but noting that 9.4 per cent of our flooded sample do not have contents insurance (Table 5), similar to the 10 per cent of households found in Stallworthy (2013). Responses to each of these three categories are summed and factored to produce 0–100 indices as described above.

4 | RESULTS: OBSERVED PATTERNS

Short-term intangible impacts stand out as greater (mean = 59) than either the short-term tangible (mean = 33) or long-term impacts (mean = 36) in Tables 3–6. For a more detailed breakdown of the magnitude of different types of impact in our data, see Werritty et al. (2007). We report key differences in reported flood impacts according to household characteristics (Table 3), flood severity and duration of displacement from home (Table 4), mitigating factors (Table 5), and location (Table 6). Observed patterns are based on simple descriptive statistics: tabulation of mean impact scores, with inferential *T*-tests.

Social differentiation appears to widen over the recovery process, with markedly greater social contrasts in long-term versus short-term intangible impacts (Table 3). Most social categories have reported short-term intangible impacts within five points of the overall figure of 59. In other words, the short-term intangible impacts (i.e., stress and strains of the response to the immediate aftermath of a flood and early recovery phase) are severe for most people, irrespective of social category or status. In the long term, however, significantly greater impacts are reported by younger people, disabled people, non-professionals, and council tenants. Short-term tangible impacts also show a degree of social differentiation, with greater scores reported by young people, those with a car, and homeowners with a mortgage.

Age and housing tenure reveal statistically significant differences for all types of flood impact, with older age groups, council tenants, and homeowners with a mortgage all reporting greater impacts. Disability, income, and occupational group are only significant for long-term impacts, with disabled people and non-professionals reporting greater impacts. Car ownership is associated with greater short-term tangible impacts but no other types of impact (presumably relating to damages to the car itself).

Home owners with a mortgage and council tenants are the most adversely affected in terms of overall aggregate and short-term intangible impacts (although council tenants report lower short-term tangible impacts but substantially greater long-term impacts). The depth of flood water in the home, the duration of time out of the home, and being flooded more than once are all associated with substantially greater reported impacts (Table 4), typically adding 15–20 "points" to reported impacts.

A limitation of the four impact indices reported here is that the aggregation method assumes linearity between "mild," "serious" and "extreme" by weighting them 1, 2 and 3 respectively. The sensitivity of the results to changing these weights

TABLE 3 Impact of flood by household characteristics (mean values on 1–100 scales for each type of impact)

		Overall		Resistance				Resilience	
Household characteristics	***n***	**Overall impact (0–100)**	**Signif[a]**	**Short-term tangible impacts (0–100)**	**Signif[a]**	**Short-term intangible impacts (0–100)**	**Signif[a]**	**Long-term impacts (0–100)**	**Signif[a]**
All households	593	44	–	33	–	59	–	36	–
Child under 10 years?									
Yes	51	44	0.749	32	0.680	62	0.0747	34	0.577
No	542	44		34		59		36	
Child 10–15 years?									
Yes	62	47	0.541	37	0.211	59	0.926	39	0.547
No	531	44		33		59		35	
Adult 16–24 years?									
Yes	75	51	**0.013**	41	**0.002**	64	0.127	43	**0.013**
No	518	43		32		58		35	
Adult 25–69 years?									
Yes	426	47	**0.000**	36	**0.000**	61	**0.001**	38	**0.000**
No	167	38		26		52		31	
Adult over 70 years?									
Yes	145	38	**0.001**	25	**0.000**	53	**0.010**	31	**0.006**
No	448	46		36		61		37	
Disabled person in household?									
Yes	90	48	0.100	34	0.944	60	0.617	45	**0.003**
No	446	44		34		59		34	
Household has a car?									
Yes	455	45	0.376	36	**0.000**	59	0.471	35	0.177
No	138	43		26		57		39	
Household income									
Under £20,000 per annum	168	44	0.967	32	0.132	58	0.584	37	0.103
£20,000–£50,000 per annum	115	45	0.743	36	0.109	60	0.626	33	0.376
Over £50,000 per annum	18	41	0.487	33	0.892	60	0.857	26	**0.046**
Occupation[b]									
Professional and associated professional	174	43	0.070	35	0.826	59	0.181	32	**0.003**
Skilled occupations	135	47	0.276	34	0.720	63	0.186	38	0.147
Semi-skilled and unskilled occupations	104	47	0.363	36	0.534	61	0.898	40	0.082
Housing tenure									
Being bought with a mortgage	210	48	**0.003**	39	**0.000**	63	**0.003**	38	0.131
Owned outright by household	226	43	0.173	34	0.505	57	0.307	32	**0.005**
Rented from council	83	45	0.670	25	**0.000**	58	0.866	45	**0.001**
Rented from a housing association or trust	12	39	0.358	22	0.052	52	0.142	37	0.937
Rented from a private landlord	13	35	0.122	24	0.126	50	0.276	26	0.124

[a]Based on the *T*-Test for equality of means, comparing each category against the rest of the sample; significance values less than 0.05 are bold, indicating a greater than 95% probability that the mean differs from the rest of the sample. [b]based on current or former occupation of main earner.

Source: Authors' survey.

TABLE 4 Impact of flood by severity of flooding, displacement from home, and prior experience of flooding (mean values on 1–100 scales for each type of impact)

		Overall		Resistance				Resilience	
Severity of flooding and displacement	***n***	**Overall impact (0–100)**	**Signif[a]**	**Short-term tangible impacts (0–100)**	**Signif[a]**	**Short-term intangible impacts (0–100)**	**Signif[a]**	**Long-term impacts (0–100)**	**Signif[a]**
All households	593	44	–	33	–	59	–	36	–
Depth of last flood									
<30 cm	221	36	**0.000**	27	**0.000**	50	**0.000**	20	**0.000**
>30 cm	336	52		40		68		43	
Flooded more than once?									
Yes	165	53	**0.000**	41	**0.000**	68	**0.000**	46	**0.000**
No	419	41		31		56		32	
Displacement from home									
<3 months (incl. not displaced)	207	36	**0.000**	29	**0.000**	48	**0.000**	28	**0.000**
3–6 months	140	50	**0.001**	36	0.115	67	**0.000**	40	**0.036**
>6 months (incl. still displaced)	204	54	**0.000**	39	**0.000**	71	**0.000**	45	**0.000**

[a]Based on the *T*-Test for equality of means, comparing each category against the rest of the sample; significance values less than 0.05 are bold, indicating a greater than 95% probability that the mean differs from the rest of the sample. None of the mitigating factors analysed has a statistically significant relationship with any type of flood impact (Table 5).

Source: Authors' survey.

was assessed by performing the analysis reported in Table 3 using an alternative weighting scheme: "mild" = 1; "serious" = 2; "extreme" = 4. This geometric scale increases the weight of "extreme" responses on the basis that some factors may have a very large impact on some households. The alternative scale reveals no statistically significant differences compared to the linear weighting.

5 | RESULTS: UNDERLYING RELATIONSHIPS

5.1 | Modelling approach

In order to explore underlying relationships within the database beyond those revealed by simple descriptive statistics, we construct multiple linear regression models with the aim of revealing the effect of various factors while controlling for confounding factors. The dependent variable in each model is the standardised 0–100 flood impact scale, as described in the methodology section. Model 1 relates to overall impact. Models 2 and 3 relate to short-term tangible and short-term intangible impacts, respectively, to reflect resistance, as defined by Cutter (2006). Model 4 relates to long-term impacts, reflecting resilience, again as defined by Cutter (2006). Because each model uses a 0–100 scale as the dependent variable, unstandardised coefficients and constants can be directly compared between models.

All covariates are categorical and therefore are coded as sets of "dummies" (1 or 0, reflecting whether belonging to a category or not), with one reference category for each set of dummies (e.g., housing tenures). Variables that do not have a reference category stated in Table 7 are binary yes/no variables, with "no" as the reference category.

All variables reported in Tables 3–6 were entered in all four multivariate models reported in Table 7. Although there is minor clustering and skewing in the data, the overall impact index conforms to the normal distribution at the 95% confidence level and the other three impact indices do not deviate substantially from the normal distribution.[4] Tests for co-linearity reveal low variance inflation for almost all variables in the models.[5] The urban–rural classification of survey sites used in the descriptive analysis cannot be included in the same model as the location dummies, because these two sets of variables are perfectly co-linear with each other.

TABLE 5 Impact of flood by mitigating factors (mean values on 1–100 scales for each type of impact)

		Overall		Resistance				Resilience	
Mitigating factors	***n***	**Overall impact (0–100)**	**Signif[a]**	**Short-term tangible impacts (0–100)**	**Signif[a]**	**Short-term intangible impacts (0–100)**	**Signif[a]**	**Long-term impacts (0–100)**	**Signif[a]**
All households	593	44	–	33	–	59	–	36	–
Contents insurance?									
Yes	512	46	0.375	35	0.124	61	0.079	36	0.358
No	53	43		30		54		40	
Received warning?									
Yes	240	45	0.772	33	0.658	59	0.704	36	0.982
No	338	45		34		60		36	
Aware of flood risk?									
Yes	186	44	0.426	32	0.328	57	0.184	37	0.813
No	392	45		34		61		36	
Took actions prior to flood?									
Yes	445	45	0.883	34	0.605	59	0.791	36	0.773
No	148	44		33		58		36	
Received assistance after flood?									
Yes	536	44	0.295	33	0.208	59	0.795	35	0.122
No	57	48		38		60		42	

[a]Based on the *T*-Test for equality of means, comparing each category against the rest of the sample; significance values less than 0.05 are bold, indicating a greater than 95% probability that the mean differs from the rest of the sample. As expected, residents from different locations in the sample report statistically significantly different magnitudes of flood impacts, largely reflecting the severity or repeated nature of the flooding: see below and Werritty et al. (2007) for further details.
Source: Authors' survey.

5.2 | Model results

The most important underlying determinants of flood impact are age (protective effect of being elderly), income (protective effect of higher income), and depth of flooding (adverse effect of deeper water), with all three consistently linked with all types of impact (Models 1–4, Table 7). Factors not statistically significantly linked to any type of impact are children, disability, car ownership, contents insurance, actions or assistance prior to the flood, and location.

Other factors have strong effects, but only for certain types of impact. Specifically, households with an adult aged 16–24 are linked with greater long-term impacts only (Model 4). Homeownership and not receiving a flood warning are both linked with greater short-term tangible impacts only (Model 2). Professional and skilled employment are both linked with greater short-term intangible impacts only (Model 3). Having been previously flooded serves to increase the short-term intangible and long-term impacts (Models 3 and 4) of the latest flooding episode (especially long-term impacts in Model 4) but not short-term tangible impacts. Time displaced from home has a strong effect on short-term intangible impacts (Model 3), but no effect on long-term impacts or on short-term tangible impacts. Finally, prior awareness of being at flood risk has a protective effect on short-term intangible impacts only (Model 3).

Of the different types of impact captured in Models 2–4, short-term intangible impacts (Model 3) have, by a large margin, the largest (and only statistically significant) constant at 28.8. This large constant represents almost half the mean value for the sample (59, reported in Table 3). The large constant suggests that short-term intangible impacts are felt strongly by all households.

6 | INTERPRETATION AND DISCUSSION

We collected information from households on the magnitude of a range of impacts arising from being flooded. We analyse and interpret our results in this section using a vulnerability and resilience framework. We adopt the influential and widely

TABLE 6 Impact of flood by location and type of location (mean values on 1–100 scales for each type of impact)

		Overall		Resistance				Resilience	
Location and type of location	*n*	Overall impact (0–100)	Signif[a]	Short-term tangible impacts (0–100)	Signif[a]	Short-term intangible impacts (0–100)	Signif[a]	Long-term impacts (0–100)	Signif[a]
All locations	593	44	–	33	–	59	–	36	–
Location									
Forres	106	37	**0.000**	29	**0.031**	51	**0.002**	28	**0.000**
Edinburgh	143	40	**0.012**	31	0.173	56	0.193	29	**0.000**
Elgin	152	53	**0.000**	39	**0.003**	69	**0.000**	47	**0.000**
Perth	70	50	**0.026**	40	**0.011**	65	**0.019**	39	0.286
Glasgow	62	47	0.512	32	0.753	59	0.947	43	**0.050**
Hawick	36	35	**0.009**	27	0.102	44	**0.003**	29	**0.043**
Scattered rural & coastal	24	37	0.113	27	0.141	50	0.137	29	0.158
Type of location									
Urban	275	44	0.753	34	0.829	59	0.858	34	0.229
Small town	294	45	0.344	34	0.765	59	0.668	38	0.082
Rural	24	37	0.113	27	0.141	50	0.137	29	0.158

[a]Based on the *T*-Test for equality of means, comparing each category against the rest of the sample; significance values less than 0.05 are bold, indicating a greater than 95% probability that the mean differs from the rest of the sample.
Source: Authors' survey.

used definition of vulnerability proposed by Cutter (2006), differentiating between three components: exposure, resistance, and resilience.

We measure exposure as depth of flood water in the home and number of times flooded. On the basis that households with greater vulnerability will report greater impacts, we represent resistance through reported short-term impacts, as the notion of resistance relates to ability to withstand in the short term. On the basis that recovery is inherent to resilience, we represent resilience through reported long-term impacts. We capture household-level social vulnerability through a range of socio-demographic and socio-economic categories. We capture community-level vulnerability through the availability or use of services (e.g., receiving a flood warning, having contents insurance).

The analysis has focused particularly on social patterns in short- and long-term impacts in order to identify social patterns in short-term resistance (ability to withstand) and long-term resilience (ability to recover). Within short-term impacts, a distinction is made between tangible (mostly material and financial) impacts and intangible impacts (mostly relating to disruption), on the basis that these are qualitatively distinct in their nature. Long-term impacts mostly relate to stress, anxiety, and well-being, which can generally be considered intangible (although long-term intangible impacts may have second-round tangible impacts; for example, chronic anxiety can have tangible impacts on health).

In terms of exposure, the depth of flood water has a strong influence on the impact on households. This is unsurprising, as flood water depth is likely to be strongly linked to the scale of damage and ensuing losses, repairs, disruption, and time out of the home. Witnessing a flood of greater magnitude and/or its aftermath may also cause greater trauma and future anxiety.

Turning to social differentiation within flood impacts, as noted by Lamond et al. (2015), lower income is likely to limit resistance to the impacts of material losses and displacement from home. In particular, lower income probably limits the ability to quickly replace essential items, deal with additional costs associated with living in temporary accommodation, organise satisfactory refurbishment, and absorb financial losses. Low income may also serve as a proxy for a range of unobserved social factors that may affect resilience, such as aspects of social capital, family relationships, and general well-being/psychological resilience. In contrast to Medd et al. (2015), we find little evidence of a link between occupational group and tangible or long-term intangible impacts, although in terms of descriptive statistical relationships professionals report lower impacts of all types (but only statistically significant for long-term impacts).

A strong effect, consistent across all types of impact, is that households with elderly members report significantly lower impacts. Households with older members may have more personal and social "capital" to draw on deriving from experience,

TABLE 7 Multivariate models of impact of flood by selected household characteristics, severity of flooding, and displacement

Household characteristics, severity of flooding and displacement	Overall		Resistance				Resilience	
	Model 1: Overall impact		Model 2: Short-term tangible impacts		Model 3: Short-term intangible impacts		Model 4: Long-term impacts	
	Beta	S.E.	Beta	S.E.	Beta	S.E.	Beta	S.E.
Household characteristics								
Child under 10 years?	1.71	3.97	−1.96	4.76	2.60	4.65	3.32	4.67
Child 10–15 years?	5.04	3.72	4.29	4.45	2.46	4.35	8.53	4.37
Adult 16–24 years?	8.19[a]	3.46	5.97	4.14	5.30	4.04	12.88[b]	4.06
Adult 25–69 years?	−4.94	4.95	−3.08	5.93	−4.62	5.79	−6.63	5.82
Elderly over 70 years?	−16.62[c]	5.05	−16.85[b]	6.05	−15.39[b]	5.91	−17.87[b]	5.94
Disabled person?	4.52	3.87	1.32	4.64	5.03	4.53	6.23	4.55
Car?	3.44	3.39	4.75	4.06	3.95	3.96	1.93	3.99
Household income								
Under £20,000 per year	14.18[b]	5.34	12.74[a]	6.40	14.50[a]	6.25	14.82[a]	6.28
£20,000–£50,000 per year	10.65[a]	5.01	10.50	6.00	11.07	5.86	10.27	5.89
>£50,000 per year (ref.)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Occupation[1]								
Professional/Ass. professional	4.80	3.52	4.86	4.22	8.70[a]	4.12	0.31	4.14
Skilled occupations	6.08	3.43	5.79	4.11	8.40[a]	4.01	3.63	4.03
Semi-skilled and unskilled (ref.)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Housing tenure								
Being bought with a mortgage	7.55	5.78	13.55	6.92	6.72	6.76	4.22	6.79
Owned outright by household	7.65	5.77	14.87[a]	6.91	7.16	6.75	3.03	6.79
Rented from council	7.91	6.61	−2.03	7.91	12.35	7.72	9.93	7.77
Rented from housing ass./trust	−5.26	9.29	−10.86	11.13	−1.44	10.87	−5.61	10.92
Rented from a priv. landlord (ref.)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Severity of flooding								
Last flood > 30 cm deep	11.78[c]	2.72	13.70[c]	3.25	11.22[c]	3.17	11.04[c]	3.19
Flooded more than once?	9.34[b]	3.28	4.07	3.93	8.33[a]	3.84	14.25[c]	3.86
Displacement from home								
<3 months (incl. not displaced) (ref.)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
3–6 months	4.52	3.19	−0.67	3.80	8.77[a]	3.71	3.37	3.73
>6 months (incl. still displaced)	8.16[a]	3.17	1.54	3.83	15.31[c]	3.73	4.71	3.75
Mitigating factors								
Contents insurance?	−2.48	5.36	−7.87	6.42	1.28	6.26	−2.93	6.30
Received warning?	−4.78	2.71	−7.23[a]	3.25	−5.91	3.17	−1.75	3.19
Aware of risk?	−3.73	2.76	−1.73	3.31	−6.74[a]	3.23	−1.71	3.24
Took actions?	1.11	3.19	−0.36	3.82	1.71	3.73	1.48	3.75
Received assistance?	−1.40	4.54	−0.69	5.44	4.49	5.31	−8.66	5.34
Location								
Forres	−8.29	6.27	−9.45	7.51	−12.01	7.33	−3.19	7.37

(Continues)

TABLE 7 (Continued)

Household characteristics, severity of flooding and displacement	Overall		Resistance				Resilience	
	Model 1: Overall impact		Model 2: Short-term tangible impacts		Model 3: Short-term intangible impacts		Model 4: Long-term impacts	
	Beta	S.E.	Beta	S.E.	Beta	S.E.	Beta	S.E.
Edinburgh	−3.59	6.17	−6.99	7.38	−1.27	7.21	−3.80	7.25
Elgin	5.42	6.41	8.20	7.68	1.82	7.49	7.56	7.53
Perth	6.23	6.89	0.71	8.25	11.00	8.06	4.73	8.10
Glasgow	5.27	9.00	5.02	10.78	−0.211	10.53	11.71	10.58
Hawick	−9.19	7.54	−13.42	9.04	−10.63	8.82	−4.53	8.87
Scattered rural & coastal (ref.)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Model parameters								
Constant (S.E. of Constant)	18.76 (12.39)		13.10 (14.84)		28.79 (14.49)[a]		11.33 (14.57)	
R square	0.448		0.383		0.415		0.415	
S.E. of the estimate	16.99		20.35		19.87		19.97	
Model significance	<0.000		<0.000		<0.000		<0.000	

Note. Dependent variable = impact on 1–100 scale for each model. S.E. = Standard Error. Ref. = Reference category for categorical variables; Ref. is "No" for all binary yes/no variables.

[a]Significant at >95%. [b]Significant at >99%. [c]Significant at >99.9%. [1]Based on current or former occupation of main earner.

Source: Authors' survey.

stoicism, knowledge, and social networks (Astill and Miller, 2018; Bei et al., 2013; Cherry et al., 2010). This may mask higher mortality among the most frail as they move into care homes or premature death as a result of having been flooded and so are not captured in our sample (Jonkman et al., 2009). Children aged 10–15 fall just short of having a statistically significant effect on long-term tangible impacts and have no effect on any other type of impact. But the strong link between having a household member aged 16–24 and greater long-term impacts may be accounted for by the time lag between the floods and our survey. In cases where these adults are grown-up "children," many would have been teenagers at the time of the flood and disruption to schooling, friendships, and privacy may have been important (Werritty et al., 2007).

An unexpected finding is the association of homeownership with greater impacts and that homeowners with a mortgage report higher scores for all types of impact. However, after controls are in place in multiple regression models, this is only true for tangible (mostly material) impacts on outright homeowners (also almost significant for those with a mortgage, with $p = .052$). Homeowners have more to lose and have to bear costs that may be covered by tenants' landlords. But council tenants differ from housing association and private tenants by reporting the greatest long-term impacts, possibly related to delays in finding alternative accommodation or being temporarily re-housed at some distance from family, friends, workplaces, and schools (Werritty et al., 2007).

None of the mitigating factors examined (having contents insurance, receiving a warning, being aware of risk prior to flood, taking actions prior to the flood, or receiving assistance after the flood) is consistently or significantly linked to flood impacts in the descriptive statistical analyses. But with controls in place in the multiple regression models, receiving a warning reduces tangible impacts and being aware of prior flood risk reduces short-term intangible impacts.

Large differences between locations reflect contrasts in flood severity, frequency, and socio-economic composition. Thus Elgin reports high impacts, probably linked to repeated flooding five years apart. Perth reports high impacts, linked to the severe nature of the flood, and Glasgow Shettleston also reports high impacts linked to high levels of social deprivation and, in this case, the rapid onset of a pluvial flood event. But after controls are in place in multiple regression models, location dummies are not significant.

7 | CONCLUSIONS

Our findings reveal that social differentiation in short-term flood impacts is relatively small but widens for long-term impacts. Overall, the most important underlying determinants of flood impact are: age (with a protective effect of being

over 70 years of age); income (with a protective effect for higher-income households); and depth of flooding (with greater depth having a more damaging effect). Some results are in some ways unexpected, in particular the greater vulnerability of homeowners and professionals to short-term impacts, and the high degree of resilience displayed by older people.

Our results reveal a depletion in resilience among those who have previously been flooded. It might be expected that greater knowledge of flood impacts, and knowledge of how to mitigate impacts, will translate to more mitigating actions and therefore ability to recover. However, although awareness and flood warnings are linked with small reductions in short-term (but not long-term) impacts, having been previously flooded has no protective effect against short-term impacts and raises long-term impacts.

Our modelling results reveal that the underlying influences on resilience to flooding are complex and may not always be evident in simple observed patterns. For instance, households with a disabled person report greater long-term impacts, but after controlling for income and other factors in multivariate models, disability is not linked to lower resilience. Disability may therefore be of concern from a justice point of view (because disabled people experience greater flood impacts), but it is more difficult to argue that disability per se serves to increase vulnerability to flood impacts. The results for income, occupation, and location also differ markedly between simple revealed and underlying modelled relationships. Care must therefore be taken when drawing conclusions about the causes of vulnerability and resilience to flooding based on simple descriptive statistics. Vulnerability and resilience are complex and multi-faceted.

The analysis reported in this paper is novel in three regards. First, it is one of the first quantitative studies to explicitly differentiate between short- and long-term flood impacts over a wide range of flood impacts, and therefore able to focus on social patterns in the recovery process. Second, it is only the third quantitative study to capture the effect of repeated flooding. Third, it is based on one of the largest and most comprehensive and representative samples of flooded households undertaken to date.

Limitations are that the data were collected retrospectively and therefore people who left flooded areas or died between the flood and the survey are excluded from the sample. Flood impacts were self-reported and are therefore subject to recall and reporting biases. Although the sample is larger than most other studies, some categories have small numbers of observations (e.g., private renters).

This paper draws five broad conclusions. These are likely to be generalisable to many situations beyond the immediate empirical context of the data reported in this paper, principally the rest of the UK, but also elsewhere in northern Europe, other developed countries, and, to some extent, less developed countries. While the interpretation of some of the findings are by necessity cast in the Scottish or UK context (for example, the nature of housing tenure and status, resources and practices of landlords), many are of general relevance. In particular, socio-demographic, socio-economic, and market-influenced factors are likely to resonate beyond Scotland and the UK. Important components of our analysis are the social patterns in the long-term recovery process and the effects of repeated flooding on vulnerability to further flooding – both of which are likely to be applicable beyond the immediate local or national context. Finally, we frame our analysis in relation to the concept of vulnerability, which is transferable between national contexts.

7.1 | Social differences in the impacts of a natural disaster widen over time

Differences between social groups in short-term flood impacts are relatively small but widen in relation to long-term impacts. Household income accounts for a greater proportion of the observed variation in long-term impacts than short-term impacts. An implication of this finding is that studies of flood impacts conducted in the immediate aftermath of a flood may underestimate the extent of social inequality that may emerge in the long term. Flood waters do not respect social boundaries, but the recovery process is driven by them.

7.2 | Households display great variation in resourcefulness, which derives from wider capitalist social relations rather than from specific vulnerabilities to flooding per se

Time and money available to households appear to be key resources. Age and income are the only factors in our models significantly linked with resilience (as measured by long-term impacts) – alongside the severity of flooding (depth and frequency). The presence of a household member over the age of 70 has a strong and consistent protective effect against all types of flood impact, including short-term impacts. Professional and skilled workers report greater short-term intangible impacts. We interpret these findings as evidence that time availability (high in retired people, low in professional and skilled workers) aids capacity to organise rehousing and repairs to property and in adapting to disruption. Policy implications arising from this conclusion are to provide time (e.g., compulsory paid leave from employment) and money (e.g., from emergency state funds) to

flood victims. None of the mitigating factors or location dummies are significant in our model of long-term resilience (Table 7). A caveat is that if assistance and support functions (termed "mitigating factors" in our analysis) are focused on the most vulnerable, then their benefit may be real but difficult to detect. Some mitigating factors (flood warnings and prior awareness of being at flood risk) have modest protective effects against short-term impacts, but not on long-term impacts. Nevertheless, the much greater importance of household characteristics than mitigating factors in our analysis resonates closely with the notion of "resourcefulness" reflecting wider capitalist social relations, derived from spatial scales and processes far beyond the flood plain, that come to bear on resilience, as argued by MacKinnon and Derickson (2013).

7.3 | Prior experience of flooding depletes psychological long-term resilience, but does mitigate short-term tangible flood impacts

Given the significance of repeated flooding in raising reported long-term impacts, a potential policy implication is to prioritise (other things being equal) flood-risk management measures in areas that have been flooded within living memory, even if they may not register the greatest future flood risk in flood-risk models. This has implications in terms of public policy. We are of course not suggesting that increasingly sophisticated flood-risk prediction models should be disregarded, but our results suggest that the strong impulse seen in many local communities in the years immediately following a flood for greater protection, which sometimes dissipates over time, may be linked to an inherent knowledge of psychological vulnerability to repeated flooding leading to community pressure for engineered defences.

7.4 | Older people have greater resilience to long-term flood impacts

Our finding that older people are more resilient to flooding replicates a similar finding in relation to the mental health of flood victims in Tunstall et al. (2006). Age (continuous measure in years rather than specifically the elderly) had no significant effect on the impacts of being flooded in Lamond et al. (2015). Thus, of the three large-scale quantitative studies of flood impacts in the UK, none finds evidence that older people are less resilient to the effects of being flooded and two find that they are more resilient. While some elderly people may be acutely vulnerable due to frailty, sickness, and immobility (Kaźmierczak et al., 2015b), older people as a demographic group are not in aggregate more vulnerable – rather the opposite. A caveat is that our survey took place some years after floods, so excludes those displaced or deceased, which will include some frail elderly. While our results show that older people as a whole report lower flood impacts, the most vulnerable elderly may have lower resilience to short-term impacts, which may result in their movement into a care home or even premature death (and thus exclusion from our sample).

7.5 | Existing indices of flood vulnerability that use multiple measures of social deprivation should be used with caution

While some aspects of conventional measures of social deprivation (in particular, low income) are linked with some vulnerabilities to flooding (particularly long-term recovery), our results confirm emerging arguments that flooding vulnerability differs in a number of regards to general social deprivation (Sayers et al., 2017). As noted in the previous section in relation to age, some categories in multiple social deprivation indices lack the necessary granularity to detect vulnerabilities to flooding. While age may be a useful proxy for other specific vulnerabilities such as poor health and lower mobility that may not be available metrics for indices to draw on, a critical question for future research is at what age people, on average, reach a certain level of vulnerability.

Bespoke flood vulnerability indices, such as the Social Flood Vulnerability Index (Tapsell et al., 2002) and the Neighbourhood Flood Vulnerability Index (Sayer et al., 2017), have been developed in order to produce measures that better reflect vulnerability to flooding rather than general social deprivation. However, these flood vulnerability indices include factors that this study has shown to be unrelated or inversely related to some or all types of flood impacts: older people, car owners, homeowners, and professional/skilled occupations (although some of these, e.g., car ownership, are used as proxies for income in the absence of local data on income in the UK, and our results do find income to be important). After controlling for household-level factors, area social deprivation (as captured by Glasgow Shettleston in our sample) and other area characteristics (as captured by other location dummies) had no independent effect on flood impacts. Indices of multiple social deprivation should be used with caution in estimating social vulnerability to flood risk, as not all deprived categories correspond with the greatest vulnerability to flood impacts. Further research is required to better inform and further hone bespoke flood vulnerability indices.

ACKNOWLEDGEMENTS

We are grateful to the Scottish Executive for commissioning and funding "blues-skies" research on social aspects of flooding and flood risk and for granting us complete freedom in research design, the data collected for which is used in this paper. We are indebted to Allan Findlay, Darja Reuschke, and Amy Tavendale for insightful comments on earlier drafts, and to Amy Tavendale for painstaking data collection and data entry.

DATA AVAILABILITY STATEMENT

We are unable to provide access to the dataset used in this paper due to the stated terms of use when consent was given by research participants, due to the funder's terms and conditions, and due to risk of disclosure arising from the richness of information recorded about households in geographically small flood envelopes.

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ENDNOTES

[1] We are not equating the term 'resistance' solely to building standards and the physical ability of buildings to repel or withstand water ingress (as the term is generally used by UK government departments and agencies).

[2] For further detail on data collection and subsequent analyses see Werritty et al. (2007).

[3] All figures for Scotland for comparison are taken from the 2001 Census of Population.

[4] Kolmogorov-Smirnov Normality Test results: (i) overall impact, $D = 0.036$ ($p = .059$), skewness = −0.033; (ii) short-term tangible impact, $D = 0.113$ ($p < .000$), skewness = 0.542; (iii) short-term intangible impact, $D = 0.091$ ($p < .000$), skewness = −0.482; (iv) long-term impact, $D = 0.111$ ($p < .000$), skewness = 0.700.

[5] Variance Inflation Factors (VIFs) in excess of 5.0: <£20 K (5.321); Owned with mortgage (5.880); Owned outright (5.607); Forres (5.134); Edinburgh (5.451); Elgin (5.901).

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How to cite this article: Houston D, Werritty A, Ball T, Black A. Environmental vulnerability and resilience: Social differentiation in short- and long-term flood impacts. *Trans Inst Br Geogr*. 2020;00:1–18. https://doi.org/10.1111/tran.12408